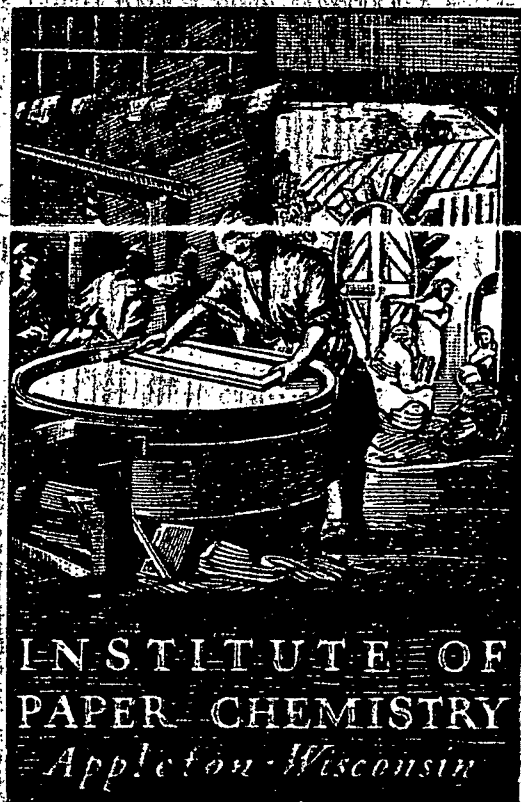

GENETIC IMPROVEMENT OF LARCH

Project 3409

Report Three

A Progress Report
to
MEMBERS OF GROUP PROJECT 3409

March 10, 1983

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

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MEMBERS OF GROUP PROJECT 3409

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THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

GENETIC IMPROVEMENT OF LARCH

SUMMARY

Interest in larch remains high, and overall progress this past year was good. Twenty-six new European larch and nine new Japanese larch trees were selected and are in the process of being propagated. These new selections bring the total number of selected trees to 118. Earlier grafting problems have been worked out, and grafting success was 96% this past year.

The planned larch first generation seed orchards, which are one major phase of the program, require considerable planning with regard to geographic location, site requirements, slope and aspect, and establishment procedures. Because of potential frost problems, Japanese larch and hybrid larch clonal seed orchards are expected to require more care in establishment than the European larch orchards.

Work on a selection index for larch was continued this past year. After working out a method for handling the growth advantage of selected trees over check trees, all that remains is to use the index to evaluate a large number of IPC selections and determine its effectiveness. When perfected, the index will make it possible to compare trees from widely separated geographic areas and eliminate, when necessary, trees that are substandard.

Four replicated larch plantings have been established on company lands. The plantings compare eight sources of larch and consisted of three container plantings and one bare root planting. Survival problems have been encountered with the container plantings, in part, apparently, because of the lack of experience in hardening-off container stock and in part because of frost injury of

the Japanese sources being evaluated. Use of improved hardening-off techniques and suitable frost-resistant sources should minimize the problem.

Isozyme investigations into methods of determining relatedness of larch clones continued this past year with the use of peroxidase banding patterns to evaluate both known and unknown sources of European larch parent trees and half-sib progeny groups. Peroxidase isozymes continue to look promising as a method of evaluation for "relatedness." It is clear, however, that two or three additional isozyme systems will be required to make the approach as definitive as needed for the seed orchard program.

Investigations into establishing base lines for judging wood quality for parent trees continued, and revised standards were prepared for use in the coming year. Wood quality standards for Japanese and European larch indicate that Japanese larch has a longer age-15 fiber length (3.2 vs. 3.0 mm), lower age-15 specific gravity (0.39 vs. 0.43), similar levels of hot-water extractives (6.0 vs. 5.9%), and higher levels of alcohol-benzene extractives (3.6 vs. 3.0%).

Larch as a source of kraft pulp was evaluated by summarizing all previous IPC larch pulping investigations and comparing the results with information from the original jack pine control pulps (55-year-old pulpwood) and data provided by an Institute member company on kraft pulps from red pine (age 22) and jack pine (age 25) pulpwood plantations. Of particular interest was the relatively poor performance (pulp yield and sheet strength) of the pulps from the red pine plantation trees. Unscreened pulp yields when adjusted to kappa 35 gave the following yields: jack pine - 44 to 45%, red pine - 45 to 46%, Japanese larch - 45 to 46%, European larch - 48%, and hybrid larch - 49%.

Comparisons with jack pine control pulps demonstrated that hybrid larch had similar CEDED bleaching chemical requirements; European larch was slightly more difficult to bleach. Japanese larch and the pulps containing 25% juvenile hybrid larch (23% bark) were the most difficult to bleach.

Comparisons of kappa 50 handsheet pulp strength data indicated European larch had pulp strengths that were comparable to the jack pine control pulps, whereas hybrid and Japanese larch refined with more difficulty and had lower breaking length. Japanese larch had similar, and hybrid larch greater tearing strength than the jack pine control pulps. Tensile energy absorption (TEA) of the larch pulps, an important property of bag and wrapping papers, was approximately equal to the values for the jack pine control pulps. Whole tree pulps from juvenile sources of larch had 20-35% lower burst and tearing strength and similar breaking length values when compared to bark-free, jack pine control pulps.

Comparisons made of kappa 30 bleached pulps included red pine and jack pine pulps from 22- and 25-year-old plantations. Comparable-age larch pulps were superior in tear, burst, and breaking length to the red pine and jack pine pulps. Red pine pulps had the lowest handsheet strength, with about 29% lower tear and 16% lower breaking length than the jack pine control pulps.

Plans for the coming year include the selection of 15 to 20 additional parent trees and the grafting of selected trees for outplanting in the IPC scion arboretum (total 650 grafts). Additional isozyme studies are planned to develop methods of determining parent tree relatedness. Establishment of a list of the highest ranked larch clones for use in the first (1985) seed orchards is also planned. Continued updating of the wood quality base-line values for evaluating parent trees for specific gravity, fiber length, and extractives is also expected to be part of next year's program. Hybrid larch seed will be sown and preparations made for the establishment of a major field planting in 1985 on company lands that will compare site preparation methods and container _vs._ bare root stock on four different soils.

INTRODUCTION

Interest in European and Japanese larch remains high. Pulping and wood quality evaluation makes the use of larch wood from 15- to 25-year-old trees for pulp production look extremely attractive. Progress this past year in the selection and propagation of potentially valuable seed orchard parent trees was good. Because the economy has prevented several potential cooperators from joining the program, the level of funding for the program remains lower than desirable for maximum progress. The report that follows gives additional details on progress made toward the goal of providing cooperating organizations with a reliable supply of good quality seed for use in the Lake States and Northeast.

SELECTION AND PROPAGATION

SELECTED TREES

Parent tree selection was again a major emphasis of the larch program Most of the available, suitable plantings in the Lake States have been visited and selections made wherever appropriate. Additional selection activity was undertaken in Maine, New Hampshire, and Pennsylvania last fall. It is planned, after all of our U.S. selections have been grafted, to bring in additional material from both Canada and Europe. Many of the foreign selections have been progeny tested and will be valuable additions to the program. Since these materials probably will be obtained on an exchange basis, we have not attempted to bring in selections earlier. Although we lack progeny-tested material for exchange, it is expected that a number of our selections will still be useful to other programs by providing additional diversity.

The selection criteria we use are similar to those of most tree improvement programs and in many instances involve more attention to wood quality. Larch is a highly variable species and lends itself well to improvement work. During the selection process we try to avoid overselecting sources from any one geographic area. Geographic origin is not always available, but it is hoped that our work with isozymes will help determine the origins of the various unknown selections. During the selection process, we evaluate a prospective parent tree for stem form, branching habit, growth rate, and crown characteristics. We take topographic information, and in a number of situations, we also evaluate soils. Ten-millimeter increment cores are taken to provide wood for extractives information, specific gravity, fiber length, and age determination. Information on frost hardiness, insect and disease problems, flowering, and time of bud break are also taken when possible.

Appendix Table XIV illustrates the form used for the evaluation of a prospective parent tree. This past year we selected or obtained 26 *Larix decidua* and 9 *Larix leptolepis*. The total number of selections is now 118. Appendix Tables XV and XVI summarize the information available on geographic origin of all larch selections.

GRAFTING AND ROOTING

Of the 118 selections now made, 45 have been established in the Greenville arboretum, and an additional 27 clones will be placed in the arboretum this spring. Figure 1 illustrates a number of larch clones and the intensive care given to assure survival and good growth. After two years in the field, a number of grafts are now 4-6 ft high. It should be noted that many of the grafts required staking both for support and establishment of good form. Scions collected from mature trees tend to have poor form during the first years after grafting. Once good growth begins and leaders are 2-3 ft long, they tend to lean when not given proper support and a chance to establish apical dominance and typical form. After establishment, a few grafts will continue to have plagiotropic growth and will not be acceptable as orchard trees. It is anticipated that these trees will need to be replaced, but this is expected to be only a minor problem.

Last year's grafting program produced 528 successful grafts. After dealing with a number of problems during the first year of grafting, a suitable and quite successful procedure has been worked out that resulted in grafting success of 96%. The losses were due primarily to understock failure and to using scion material that had been stored too long.

The changes in procedure were mainly cultural. During previous grafting, rootstock tops were cut back too far and too quickly, producing excessive stress.

Figure 1. Of the 118 larch selections made, 45 have been established in the Greenville scion arboretum with an additional 27 to be added this spring. The vigor and good growth of a 2-year old graft is illustrated in the photograph on the left. The intensive cultivation and care of the arboretum is apparent in both photographs, and it is highly recommended that the same level of care be given to properly establish larch seed orchards.

In addition, grafting rubbers used to hold scion and understock in close association were cut too soon, and often the union separated. Additional changes included increased misting and shading in an attempt to maintain cool temperatures (60-70°F) during the first weeks after grafting. It has also been necessary to pot up and grow the understock one year prior to grafting to allow it to become well established and to avoid grafting on understock of poor vigor. The types of grafts used remained the same: veneer side graft and cleft graft. The cleft graft, because of its ease of production, was employed more than the side veneer; it is equally suitable and will be used whenever possible. Figure 2 shows the two different types of grafts. Our experience has shown the cleft graft to be a stronger, more windfirm graft than the side veneer during the first years after formation.

Figure 2. Illustrated are the two types of grafts being used to propagate the larch parent tree selections. On the left is a side veneer graft in which the top of the root stock is left intact until the graft union is well healed. On the right is a cleft graft in which the top of the root stock is removed and the lower branches remain intact until the graft union is well healed. After satisfactory growth of the scion, all tops and branches of the root stock are removed.

Field grafting was attempted on a small scale last spring to gain insight into what might be expected if this approach was tried. One of the major advantages would be the establishment of the understock (root stock) in position one to two years prior to grafting. This would assure vigorous root stock and give time for good intensive care of the orchard site. Although our grafting success was high during this initial field grafting attempt, there were enough problems to raise doubts about its feasibility. Field grafting is more time-consuming than bench grafting; it is more difficult in the sense of the mechanics of having material available for each grafter, i.e., the wax, grafting rubbers, shears, and scions. It would also be necessary to have scions from all clones in the orchard available at the time of grafting, which presents a storage and handling problem. The method is still not without merit but does not appear as useful as first anticipated.

Another method of propagation investigated was rooting. The form problems and low incidence of rooting associated with cuttings taken from mature trees, as discussed in last year's annual report, has eliminated this approach. Work with hedging did produce multiple shoots, but because of time and budget constraints a rooting trial of this source of material was not initiated. Cuttings collected from a mature tree that has been hedged generally root better than those collected from an untreated mature tree. Through hedging, a phase change is initiated and the plant becomes more juvenile, making it easier to root. However, by returning the plant to a juvenile state, the early flowering ability that occurs with grafts has been lost. The high rate of success obtained with grafting has essentially eliminated the need for rooting of the parent tree clones.

A rooting trial was set up to evaluate the rooting of young (7-month-old) seedlings by using three treatments. The trial was undertaken to determine the feasibility of increasing the amount of planting stock from a limited quantity of high value seed. This was of particular interest in view of the problems encountered in obtaining large quantities of hybrid larch seed and the generally low germination of the small seedlots we were able to obtain.

Larch is known to root readily, perhaps one of the easiest conifers to root. The trial was set up using 7-month-old Larix decidua that was growing in our greenhouse. The treatments consisted of a 2-hour basal soak in 100 ppm indole butyric acid (IBA), a basal dip in Hormodin #3 (0.8% IBA), a basal dip in Captan WP50, and a basal dip in talc only (control). The cuttings for each treatment were collected, immediately treated, and stuck in 80-hole styroblocks containing a perlite:sand:German peat rooting medium (1:1:1 v:v:v:). There were four replications, with each styroblock representing one replication of each of the treatments. The cuttings were watered and hand misted prior to covering each styroblock with a polyethylene tent. The summary of rooting results is given in Table I. After 60 days, the best results were obtained with treatment 3, the Hormodin #3 basal dip and treatment 2, the 2-hour basal soak of 100 ppm IBA. Both were IBA treatments; IBA is a hormone frequently used to induce rooting.

TABLE I

LARCH

Greenwood Cutting Rooting Trial

Treatment	% Well Rooted	% Poorly Rooted	% Unrooted	% Dead
1 Basal dip - Talc	9	18	65	9
2 2-Hour basal soak 100 ppm IBA	58	18	14	11
3 Basal dip - Hormodin #3	66	18	12	4
4 Basal dip - Captan WP50	4	34	58	5

The method used to induce rooting could be easily adapted to any greenhouse, and given the high level of quality rooting, it probably could be a satisfactory technique for mass production of additional quantities of high quality stock. The stems from which the cuttings are taken quickly produce other shoots, generally with one shoot establishing dominance. A similar technique has been used for black and Norway spruce (1,2).

SEED ORCHARD PLANS

We have been encouraged by the success of our grafting program and by the adequate number of clones that we now have available for seed orchards. It should be emphasized that the 118 clones we have to select from for the first orchards do not represent all of the material that will be available. Because of the need for a sustained supply of good quality larch seed, the best approach appears to be the establishment of orchards of phenotypically superior selected parent trees as soon as possible. Next, if cooperator input demonstrates there is interest in further upgrading of selections, progeny testing should be undertaken and those selections with poor performance rogued from the program. By not waiting for progeny testing and going ahead with seed production areas using the best materials available means that small quantities of seed will be available within 12-15 years from establishment. Taking the conventional approach of progeny testing prior to seed production would mean that those selections to be tested need to flower and produce sufficient seed for full-sib progeny testing. After the seed is in hand, which could be 2-5 years or more depending on the availability of the selection, there is an additional 15-20 years of progeny testing before the best selections can be determined. It is at that point that propagation can begin for seed orchard establishment and another 12-15 years before seed from the orchard is available. Accepting seed from the production orchards being proposed, without initial progeny testing, means that reasonable quality seed will be available at least 20 years earlier than from a more conventional approach. Progeny testing can be instituted down the line, but in the interim, seed of reasonable quality can be available for what is felt to be minimal risk.

The types of orchards being suggested are Larix decidua, L. leptolepis, or a hybrid orchard consisting of a mixture of L. decidua and L. leptolepis clones.

Seed Orchard Care and Production

Considerable attention needs to be given to the proper selection of a seed orchard site. The sole function of the orchard is to produce seed, and all factors affecting flower and seed development need to be considered. A discussion of seed orchard location and needs is given in Project 3409, Progress Report Two. Frost damage continues to be a major consideration for both orchard location and choice of orchard. Japanese larch, with few exceptions, is quite frost prone, and any orchard with Japanese larch must be situated where frost danger is minimal. Frost damage to European larch does not appear to be as severe, although it too should be located on as frost free a site as possible.

Orchard care will require a commitment and an investment in a modest amount of equipment (if not already available). The orchard must be protected from insect and animal damage and needs to be kept clean cultivated for the first years to assure the best growth and survival possible. After establishment, the orchard will continue to need maintenance, including mowing, fertilization treatments, continued insect, disease, and animal control, and possible flowering treatments.

The size of an orchard is determined by the quantity of seed a given cooperator anticipates needing and by the frequency of flowering and production rate of the materials in an orchard. Although the periodicity of larch flowering here in the Lake States is for the most part unknown, our experience with European larch on a good site in southwestern Wisconsin has shown only one year of reasonable flowering in the past four. What the flowering interval is on a more stressful site has not been documented but will be observed over the coming growing seasons.

However, to gain insight into seed production, seed yield, collection time, extraction problems, and germination, small lots of cones from several larch species have been collected. The number of cones per tree varied considerably within the same planting, due in part to crown exposure. More uniform production is expected with the wide spacing of materials in seed orchards.

The data presented in Table II represent single tree cone collections except where indicated. The variation between trees for cone production, seed production, and germination efficiency is quite evident. Although these collections may not represent actual production rates in a managed orchard, they do serve as guidelines for estimating seed production.

The seed orchard production estimates given in Project Report 1 appear to be valid based on the information received from this year's collections. Calculations indicate that good seed production for Japanese larch would be in the range of 300 lb per 8-acre orchard and at least 99 lb for European larch. The seed data for calculating the European orchard production are based on only one extraction of this year's cones, and most of the seed still remains in these cones. European larch seed is difficult to extract, and work is under way to determine the best procedure. Kiln extraction, used for many conifers, is not a satisfactory method for European larch. The effects of collection times, cone storage, and low-temperature heat application are now being evaluated. Discussions with European cooperators who are collecting cones from established larch orchards indicate that much of their *L. decidua* seed is removed by subjecting the cones to a mechanical action that breaks up the cones. Although a portion of the seed is damaged, the amount lost is less than what is left in a cone when only a nonmechanical heat application is used. Applying a mechanical treatment to remove the seed remaining in the cones collected this year would result in a considerable increase in the amount of seed extracted and thus increase the seed production estimates for European larch.

TABLE II

LARCH CONE AND SEED COLLECTIONS

Species	Age	Cones/ Tree	Seed Extracted, grams	Number of Seeds/Tree	% Germination
Larix dahurica	22	2070	432	122,658	21
	22	2760[a]	185	52,527	26
	22	115	19	5,394	33
Larix gmelini	22	1556	206	65,314	12
	22	3112	592	187,698	21
Larix leptolepis	22	482	187	39,720	40
	22	1086	315	66,907	29
Larix decidua	24	1572	164[b]	34,643	c
	24	1100	57[b]	12,040	c
	24	472	39[b]	8,238	c
	24	314	24[b]	5,070	c
	27	1258	109[b]	23,025	23
Larix laricina	50+	11,773[d]	71[d]	59,464[d]	c

[a]Cones were open during collection and part of the seed was lost.
[b]Seed from first extraction.
[c]Seedlots composited -- germination is in the process of being determined.
[d]Composite of 3 trees growing in closed stand with the bulk coming from 1 tree.

TABLE III

LARCH SELECTION INDEX

Tree No. LL-6-80

Credits		
Volume ÷ age x 20	9.4	
Growth advantage	9.3	
Straightness 1-5	3.0	
Branch weight 1-5	3.0	
Form factor ÷ 10	7.6	
		Total (+) 32.3
Deductions		
Crown exposure x 2	0	
Site index ÷ 10	9.5	
Crown area ÷ age	3.2	
		Total (-) 12.7
Wood Quality		
Age 15 specific gravity x 20	(+) 7.1	
Age 15 fiber length x 2	(+) 5.6	
Heartwood total extractives ÷ l.age	(-) 5.8	
		Total (+) 6.9
Selection Index		26.5

Selection index = credits - deductions + wood quality

Volume = $D^2 \times f^2 \times H$

Form factor = f = d.i.b. at 16.5 ft ÷ D

D = d.b.h. o.b.

H = total height

TABLE IV

LARCH SELECTION INDEX

Tree No. LL-1-80

Credits

Volume ÷ age x 20	8.5	
Growth advantage	0	
Straightness 1-5	4.0	
Branch weight 1-5	3.0	
Form factor ÷ 10	7.6	
		Total (+) 23.1

Deductions

Crown exposure x 2	2.0	
Site index ÷ 10	9.3	
Crown area ÷ age	3.5	
		Total (-) 14.8

Wood Quality

Age 15 specific gravity x 20	(+) 8.4	
Age 15 fiber length x 2	(+) 6.6	
Heartwood total extractives ÷ 1.age	(-) 9.3	
		Total (+) 5.7

Selection Index 14.0

Selection index = credits - deductions + wood quality

Volume = $D^2 \times f^2 \times H$

Form factor = f = d.i.b. at 16.5 ft ÷ D

D = d.b.h. o.b.

H = total height

ESTABLISHED FIELD PLANTINGS

GLATFELTER PLANTINGS

A number of larch plantings in the eastern U.S. have been visited, several of which have been established by the Glatfelter Pulp Wood Company. Their planting program involves primarily Japanese larch and a pitch x loblolly pine hybrid. Discussions with their chief forester regarding his experience with establishment, growth, insects, and diseases provided several useful comments. Insect problems have been primarily with the larch casebearer and gypsy moth. Glatfelter has an active parasite introduction program, utilizing both bacteria and predatory wasps to control the casebearer. They feel it has been successful, and casebearer problems are now relatively minor. Gypsy moths are a problem, but this is also true of many of the tree species in that particular region. Being unfamiliar with gypsy moths, it was quite revealing to observe the number of egg masses present on individual stems. Glatfelter feels there is a potential problem with gypsy moths, not only with larch but also with other species. They are unsure of how to control them and are waiting for guidance from those organizations working on gypsy moth control. An insect of concern in the Lake States, the larch sawfly, is present in minor numbers in Pennsylvania and has not been a problem.

Disease problems have been nonexistent with the exception of a minor needlecast problem in a small planting of European larch. The needlecast has been present for several years but is apparently not serious. We collected needle samples from infected stands and sent them for identification to Dr. Michael Ostry, a USFS pathologist working with needlecast in the Lake States. He was unable to isolate a causal organism, and we are uncertain whether or not the organism producing needlecast in the Lake States is the same one present in Pennsylvania.

Most of the Glatfelter plantings have been put in on old field sites utilizing the herbicide amizine. A sprayer has been mounted on a tree planter, and the herbicide is applied at the time of planting, ahead of the stock. Glatfelter strongly supports site preparation and considers the dollars well spent and necessary. Their best larch sites are of limestone origin with enough clay fraction to hold moisture; the higher pH sites are preferred. European larch has not done well on the poorer sites, and Japanese larch is the preferred species for the lower quality sites. This comment reinforces our observation of Japanese larch's ability to become established on lower quality sites. Spacing has been rather tight in the past but has been increased to 10 feet by 7 feet, and they are in agreement with spacings up to 10 feet by 10 feet.

A number of good parent tree selections have been made. Most of the selections have been about 19 years of age with heights of 50-58 feet and diameters of 7-9 inches b.h. (Fig. 3.) Wood quality determinations have indicated that the majority of these selections are above average. Although Glatfelter is not a member of the larch project, cooperation in providing access to their plantings, providing assistance during the selection and measuring process, and taking the time and care needed to collect scions for the requested dates has been willingly extended to us for the past three years.

RIPCO LARCH TRIAL I

During the early stages of the IPC tree improvement program with <u>Populus</u>, interest in larch also developed. European and Siberian larch were extremely important forest species in Western Europe, Russia, and Japan. American foresters and geneticists acquainted with these species were enthusiastic about the excellence of native stands observed.

Figure 3. A 17-year-old planting of Japanese larch growing in south central Pennsylvania on Glatfelter Pulp Wood Company lands. Selected trees from this planting averaged 51 feet in height and 8.6 inches d.b.h. Japanese larch is the preferred species for use on their higher pH, calcareous sites.

The rapid growth of certain larch hybrids had been widely recognized, and polyploidy in larch was also an approach that looked promising. A vigorous larch triploid was known to exist, and it appeared that the genus Larix was one of the few conifers that could be improved by the polyploid method.

Based upon growth observations and improvement possibilities, the Institute obtained several larch seed sources and placed them in small outplantings for study. Seed source was known to be an important factor in the success of other plantings in the Lake States and Northeast and was an additional reason for obtaining a number of seed sources of known origin.

Larch Trial I was established in 1957-58 on an aspen test trial area near Sugar Camp, Wisconsin. The soil type is Vilas fine sandy loam. Average rainfall from April through October is 22.7 inches.

A block of 2-0 hybrid larch was planted in 1957, and smaller blocks of 2-0 L. dahurica, L. decidua, L. polonica, and 2-2 L. leptolepis were planted in 1958. Table V presents the growth data for these sources over a 25-year period. It should be noted that the age of the hybrid source is one year greater than the column heading indicates; it was more efficient to measure all of the larch at one time than to return to the planting in successive years. The growth of the hybrid is less than would be expected (Fig. 4). The seed source for the hybrid was provided by Dave Cook and was collected from a single F_3 hybrid tree in one of his plantings. The growth data presented in Table V for the hybrid indicate it has slower growth than all but one of the other four sources. The hybrid source in this planting is not indicative of what is to be expected when an F_1 seed source from a mixed orchard of European and Japanese larch is used. The variability within the hybrid block of Larch Trial I is greater than average and is related to the seed source. Seedlings derived from seed collected from hybrid trees that were pollinated by hybrid trees have a high proportion of poorly formed and slower growing individuals.

In 1968, a buildup of larch sawfly from 1965 was producing excessive defoliation, and a decision was made to spray the planting with malathion. Sawfly control following spraying was very good, and no significant damage has occurred since the spraying, although there remains a low-level presence. Larch casebearers have also been present but at such a low level that they have to be actively searched for.

A porcupine caused damage to a number of trees in the trial several years ago but was removed, and no further damage has occurred. The L. decidua source was heavily damaged by what was believed to be red squirrel cone clipping and cutting of current season growth. All of the damage occurred in the single block of L. decidua and contributed to the poor growth being reported.

TABLE V

25-YEAR GROWTH DATA

Larch Trial I

Ripco Test Area

Material	5th Year Av. Ht. feet	10th Year Av. Ht. feet	10th Year Av. d.b.h. inches	15th Year Av. Ht. feet	15th Year Av. d.b.h. inches	20th Year Av. Ht. feet	20th Year Av. d.b.h. inches	25th Year Av. Ht. feet	25th Year Av. d.b.h. inches
L. polonica	11.0	25.4	4.2	36.8	5.7	44.9	7.0	51.5	7.6
L. decidua	7.2	17.2	2.6	27.9	4.6	34.2	5.5	42.5	6.0
L. dahurica	11.7	23.4	4.1	36.9	5.6	46.8	6.7	58.4	7.5
L. leptolepis	12.2	24.1	4.1	38.6	5.7	48.4	6.7	58.1	7.3
Hybrid[a]	11.5	23.8	3.6	35.1	5.0	44.0	5.8	54.4	6.5

[a]Hybrid values are for one year older than indicated. Seed source for hybrid stock was an F_3 hybrid, thus exhibiting higher than average variability.

Figure 4. The Japanese larch in the upper photo was one of the best performers in Ripco Larch Trial I. Growth for this material averaged 58 feet in height and 7.3 inches d.b.h. after 25 years. There is a need to be cautious in planting Japanese larch in areas of late spring frosts. The hybrid larch shown in the lower photograph has not done as well as most of the other materials. The hybrid seed used to establish this material was collected from an F_3 hybrid in New York and, as a consequence, the resulting seedlings were highly variable in performance. F_1 hybrid seed from a mixed orchard of Japanese and European larch clones is expected to produce better and more uniform growth.

The growth of L. leptolepis and L. dahurica (Dahurian variety of L. gmelini) is the best performance of the five materials planted. Although the Japanese larch is doing well (Fig. 4) and has done well in Larch Trial III (see Project 3409, Report One), a question remains about the climatic suitability. However, there is some indication that there are Japanese larch seed origins that are more suitable for northern climates than others. A number of different seed origins are being used in the Project 3409 replicated trials; these trials should provide an evaluation of their suitability. The Dahurian larch (L. gmelini) is an eastern Siberia origin and has shown good adaptability in both larch Trials I and III. Sources of known origin L. gmelini seed are being sought for use in future project plantings for further evaluation. A L. gmelini x L. leptolepis hybrid has shown good growth in Korea and Japan and also has improved frost hardiness. It is another type of larch hybrid that may warrant inclusion in Project 3409.

REPLICATED FIELD PLANTINGS

POTLATCH CORPORATION

The larch trial established by Potlatch near Cloquet, Minnesota, was one of two put in by cooperators this past spring. The seed sources included three Japanese larch, four European larch, and one hybrid. All seedlings were grown in styroblocks by Potlatch.

The area selected for the 1982 trial was a cutover hardwood site that had been planted to red pine. Heavy returning grass and herbaceous competition reduced growth and survival of the red pine. The area was sprayed with glyphosate, disked, and scarified during the two years prior to planting. The larch trial was established by planting container stock in scalped furrows.

The area was planted in June and visited in August. Returning vegetation was quite heavy. Survival and vigor were quite good, although only part of the stock (less than 25%) had reflushed and continued to grow. It appeared that partially shaded individuals were doing better than those exposed to full sunlight. A similar observation was made in an earlier larch conversion planting put in by Consolidated Papers. Light shading during establishment may reduce planting shock.

The appearance of the trial indicated that if the material survived the winter without excessive animal damage, growth should be good this spring. The area will be visited again this coming growing season and its growth and survival evaluated.

SCOTT PAPER COMPANY

All of the replicated trials, with the exception of the Scott trial, have been container plantings. Nursery seedbed production of bareroot stock for replicated trials was lower than anticipated. Only enough stock of seven of the sources was produced in sufficient numbers for a replicated trial, and this material was shipped to Maine for Scott's trial.

Four sources of European larch, two sources of Japanese larch, one hybrid source, and one tamarack source from Maine were the materials used. The planting site had previously been under cultivation and was disked prior to planting. Vegetative competition developed to a greater degree than anticipated, and a directed herbicide spray may be needed this coming growing season to release the materials.

Survival has been good for all materials. First-year growth was variable, but the best materials were the hybrid source, one of the European larch sources, and one of the Japanese larch sources. The tamarack source and the remaining Japanese larch source had the poorest performance. Growth and survival will continue to be monitored. What replacement stock is available will be used to bring the trial to as full a stocking level as possible. Although survival is an aspect of evaluation, it is necessary to have enough trees to fully evaluate growth, form, wood properties, climatic suitability, and insect and disease problems. Early mortality, unless a specific problem is noted, is difficult to assess.

Several of the seed sources are common to all replicated trials planted to date. If cooperators request additional trials, new seed sources will be tested along with seed sources common to all previous plantings. The Scott trial will also allow a preliminary comparison of bareroot stock with the container stock of the other replicated trials.

UPDATE OF EARLIER PLANTINGS

Consolidated Papers, Inc.

One of the two replicated trials established in 1981 was planted in August using container-grown stock. The planting is located northeast of Argonne, Wisconsin, on a medium quality hardwood site that had been cleared for farming. The field on which the trial was located had a dense cover of quack grass. The area was sprayed with glyphosate prior to planting. Past problems with mechanical site preparation, without routine maintenance, often developed after heavy, returning vegetative competition encroached on disturbed areas. One problem was often traded for another. To minimize returning vegetation, a decision was made to hand plant directly into the sod mat, after herbicide treatment, with as little disturbance to the site as possible. Unfortunately, the herbicide treatment was only marginally effective, and quack grass quickly returned.

The planting stock was succulent when outplanted in August, and evaluations taken at the end of September indicated that a high proportion of the Japanese larch had suffered frost damage. Observations the following June revealed high mortality in all three of the Japanese larch sources. The European larch and tamarack sources had minor to no mortality, and the hybrid source had moderate mortality. All of the mortality has been attributed to frost. One of the Japanese larch sources was replaced.

The poor grass control resulted in heavy returning vegetation, both annual broadleaf and quack grass. A release herbicide treatment using glyphosate and a shield was applied in 1982 in an effort to salvage the trial. The control was good, and the materials went into the fall in reasonable condition. The trial will be observed early this spring, and those blocks of Japanese larch not replaced earlier will be planted with other available sources.

Mosinee Paper Corporation

The second trial established in 1981 was planted on Mosinee Industrial Forest lands near Gordon, Wisconsin. The site was an old field that had been planted to red pine and had partially failed. Part of the field was fenced and sprayed with glyphosate. After the herbicide treatment the area was plowed and disked. The same larch sources planted in Consolidated Paper's trial were planted in Mosinee's trial on June 17, 1982. All of the stock was succulent and quite small, with root systems that barely held the container soil plug together. The tamarack source was quite marginal in planting condition, and only one replication was planted, with the remainder grown for an additional period and planted at a later date.

The bare soil and succulent stock produced a severe problem with groundline injury that resulted in high mortality throughout the trial. All materials were replanted in August 1981, following a spot treatment with glyphosate to reduce competition from returning annuals. Observations in the spring of 1982 indicated heavy frost damage to the Japanese larch sources and moderate damage to the hybrid source. Survival was good, but returning vegetation was quite heavy. A directed spray of glyphosate was applied in June 1982 to all materials and was very effective. Observations in August 1982 indicated that most trees were vigorous and recovering from the frost damage with the exception of the Japanese larch.

Both the Mosinee and Consolidated larch trials have had establishment problems. Vegetative competition was anticipated; control measures were inadequate but will be more effectively dealt with in future plantings. Unfamiliarity with container larch stock led to both frost and groundline injury. Frost damage to Japanese larch was expected but there is a need to evaluate known sources for possible selection of an acceptable provenance. Although all three Japanese larch sources had high levels of frost damage, one of the sources had lower damage than the other two and may be acceptable if established properly. Both trials will be observed this coming year.

ISOZYME RESEARCH

Investigations have been under way for more than 2 years into the possible usefulness of isozyme banding patterns in determining the "relatedness" of parent trees. Isozymes are the different molecular forms of the same enzyme which apparently evolve in species to fulfill specialized metabolic requirements. The objective of having "relatedness" information is to reduce inbreeding by putting only nonrelated trees in the same seed orchard.

Materials and Methods

Earlier progress reports described work on sampling and extracting procedures developed for evaluating larch needle samples for isozymes. Of the 25 isozyme systems evaluated, 4 of the most promising were examined using European larch selected parent trees and half-sib European larch progeny groups as a source of plant material.

Prior to the first frost, needle samples were collected from 12 parent trees and 3 trees from each of 3 half-sib progeny groups. To simplify evaluation procedures, the same extraction procedure was used for all 4 enzymes. The extraction procedure was effective for peroxidase, but extraction problems were encountered with the other 3 enzymes. It appears that modification of the extraction procedure will be required to screen trees for banding patterns for acid phosphatase, ribonuclease, and glutamic-oxalacetic transaminase. Only the peroxidase results are reported in the discussions that follow.

There are at least two approaches that can be used in examining this type of data. One is to look for similarities that would identify geographic larch sources; this would be useful in identifying trees of unknown origin. A second approach is to look for individuals within geographic origins that are different from the others and use them as parent trees when establishing seed orchards.

Results

Table VI lists the parent trees sampled and the peroxidase banding patterns obtained. Each of the bands in the banding patterns was assigned a specific letter, and the +'s that are shown in Table VI indicate the presence of a band at that location. Table VII summarizes the half-sib progeny groups and the associated peroxidase bands obtained. This first try at comparing enzyme patterns of trees of known and unknown origin (Danish seed orchard) was a mixed success. First, it should be recognized that the data available in this comparison are very limited, and in many instances tree origin records are poor and sometimes confusing. There was one consistent pattern which indicated all selected trees (and all half-sib progeny) had isozyme bands at positions H, J, K, and L. A check on earlier data for Japanese larch revealed that Japanese larch does not have peroxidase band H, making separation of the two species a possibility using only one enzyme system.

Another comparison that was part of this study was to provide the Biochemistry Group with needle samples of four trees and ask that they be checked for "relatedness," knowing in advance there was almost no chance the trees were related. The results of this comparison were four distinctly different peroxidase banding patterns.

TABLE VI

PEROXIDASE ISOZYME PATTERNS OF PARENT TREE SELECTIONS

		Isozyme Banding Patterns														
Tree Number	Origin	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
LD-12-80	Sudeten	+	+	+					+		+	+	+			
LD-13-80	"	+	+	+	+	+	+		+	+	+	+	+	+		
LD-14-80	"	+	+	+	+	+	+		+	+	+	+	+		+	+
LD-15-80	"	+	+	+	+	+	+		+	+	+	+	+			
LD-1-81	"								+		+	+	+			
LD-17-80	Polish								+		+	+	+			
LD-19-80	"	+	+	+				+	+		+	+	+			
LD-22-80	"	+		+					+		+	+	+			
LD-2-81	"	+	+	+				+	+		+	+	+			
LD-4-81	"	+	+	+	+	+	+	+	+	+	+	+	+			
LD-20-80	Unknown[a]	+	+	+					+	+	+	+	+			
LD-3-81	"	+	+	+					+		+	+	+			

[a]Selected trees from a Danish seed orchard.

The banding patterns of the selected parent trees demonstrated there was considerable variation between trees, and in only one or two instances does it appear that there is any problem with regard to relatedness. Trees LD-1-81 and LD-17-80, trees LD-3-81 and LD-12-80, and trees LD-2-81 and LD-19-80 are trees in which the two trees of the pair had similar banding patterns. Since, in the case of LD-1-81 and LD-17-80, it is known they are of different geographic origin, the results suggest testing for an additional enzyme will be required to demonstrate known geographic differences. LD-3-81 (origin unknown) and LD-12-80 (Sudeten) appeared to be similar and suggest LD-3-81 may be of Sudeten origin. Further checking appears required, however, because LD-12-80 is apparently quite different from the other Sudeten sources. LD-2-81 and LD-19-80 are both Polish sources and appear very similar in terms of peroxidase isozyme patterns. If evaluation by 2 or 3 additional enzyme systems confirms the similarities between these two trees, it would appear that they should not be used in the same seed orchard.

TABLE VII

HALF-SIB PROGENY PEROXIDASE ISOZYME PATTERNS

Progeny No.		Origin	Banding Pattern											
			A	B	C	D	E	F	G	H	I	J	K	L
XLD-3-79	S-1	Sudeten								+		+	+	+
	S-2	"	+	+	+				+	+	+	+	+	+
	S-3	"	+		+		+			+		+	+	+
XLD-4-79	S-1	East German	+	+	+				+	+	+	+	+	+
	S-2	"	+		+		+			+		+	+	+
	S-3	"	+		+		+			+		+	+	+
XLD-5-79	S-1	East German	+		+		+			+		+	+	+
	S-2	"	+		+		+			+		+	+	+
	S-3	"	+		+		+			+		+	+	+

The half-sib progeny groups at first glance seem to differ more one from the other, in terms of within progeny group variation, than anticipated. However, if one considers that all that is known about each progeny group is that the 3 seedlings in each group have a common maternal parent, it becomes apparent there may be a good reason for the within progeny group variation. Progeny group LD-5-79, for example, might be represented by 3 full-sib individuals and LD-4-79 by 2 full-sib individuals (which are much like LD-5-79). Only LD-3-79 might consist of 3 trees that are truly half-sib progeny.

The overall results of this very limited and inconclusive first try can be summarized as follows:

1. The peroxidase system seems to have considerable promise in determining "relatedness" in larch species.
2. Additional enzyme systems will be required to make the approach as definitive as we would like.
3. Future work must involve the use of full-sib progeny, half-sib progeny, and additional parent tree selections of verified regional origin.

WOOD QUALITY EVALUATION

SELECTED TREE DATA

Wood quality evaluation is an important aspect of the larch tree improvement program. Obviously it would be highly undesirable to select, propagate, and begin producing seed for large-scale plantings, only to find serious wood property deficiencies. From the pulp and paper point of view, wood density (specific gravity), fiber length, and extractives (alcohol-benzene and hot-water) are considered to be important wood properties. Equally important, selecting trees for the above properties will very likely have beneficial effects on the wood quality of the trees if used for solid wood products.

With the need to be sure that adequate wood quality is maintained, the establishment of base lines for the evaluation of selected trees is under way. The procedure used has been to measure wood properties whenever possible and add these data to our base-line information as it becomes available.

Specific Gravity

The specific gravity values used in comparing parent trees are based upon ovendry weight/green volume measurements using two breast high 10-mm increment cores from each tree. Although complete cores are also used in measuring selected tree specific gravity, parent tree comparisons are based on rings 14-16. For most of the trees, except those which are over 25 years of age, rings 14-16 are in the sapwood and contain only small amounts of extractives. For trees older than 25 years of age, extractive levels should be considered when evaluating the specific gravity of individual trees. Table VIII, which compares the wood properties of Japanese and European larch, illustrates the modest wood density advantage of European larch and gives the variation encountered among individual trees.

TABLE VIII

BASE-LINE WOOD QUALITY VALUES FOR JAPANESE AND EUROPEAN LARCH[a]

Wood Property	Japanese Larch	European Larch
Specific Gravity		
Age 15	0.388 (27)[a]	0.428 (38)
$s/\sqrt{n}$	0.010	0.008
* * * * *		
Fiber Length		
Age 15	3.2 (27)	3.0 (30)
$s/\sqrt{n}$	0.06	0.06
* * * * *		
Extractives		
Alcohol-Benzene, %	3.6 (22)	3.0 (38)
$s/\sqrt{n}$	0.4	0.3
Hot water, %	6.0 (22)	5.9 (34)
$s/\sqrt{n}$	0.5	0.4

[a]Number in parentheses gives the number of trees used in obtaining the indicated means.

Fiber Length

Fiber length measurements were made using the same breast high increment core samples that were used for specific gravity. Fiber length measurements were made on rings 11-15 and on 14-16 by projecting and measuring 600+ fibers (tracheids) for each sample. The data obtained on selected trees were used to establish preliminary base-line values for comparing parent trees. This age-15 information is summarized in Table VIII. To better visualize how a newly selected tree compares with the age-15 base-line information from earlier selected trees and trees used in pulping studies, Figure 5 was prepared. Plotting the value for a newly evaluated tree on the base-line figure provides an appropriate basis for comparison. When trees are marginal in other important characteristics (growth rate, form, potential disease problems, etc.), lower-than-average fiber length may result in elimination of a selected parent tree from the program. Our data to date indicate that age-15 fiber length of Japanese larch is a little longer than European larch (3.2 mm vs. 3.0 mm). The differences between species appear real, and it does not appear possible to combine the data for the two species and establish a single base line.

Extractives

Extractives levels are important because they influence specific gravity values, pulp yield, and bleaching chemical requirements (particularly hot-water extractives). Alcohol-benzene extractives and hot-water extractives were determined on the interior ten rings of breast high 10-mm increment core samples and as such represent values for heartwood for trees of age 15 or greater. Tappi Method T 204 os-76 was used for alcohol-benzene extractives, and a modification of the same method was used for hot-water extractives. Separate samples were used for each determination, and the results obtained were expressed as the percent dry weight. Table VIII summarizes the extractives data. Japanese larch has a higher level of alcohol-benzene extractives and about the same level of hot-water extractives as European larch. Levels reported continue to be less than reported for older, slow-growing trees. There also appears to be some evidence that extractive levels in heartwood are age dependent (increase with tree age), and some method of adjusting for tree age may be required when comparing parent tree extractive levels.

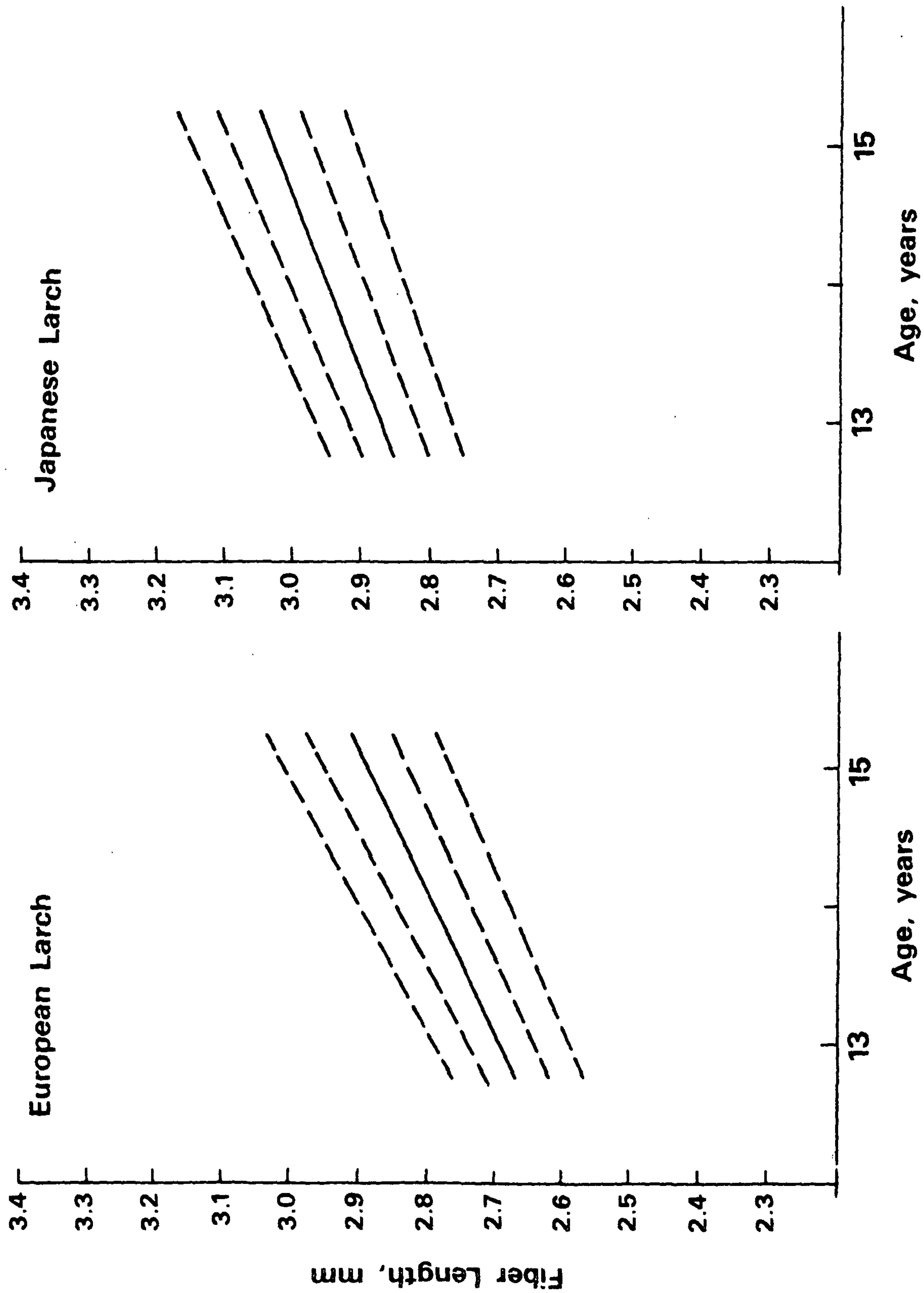

Figure 5. Fiber length base-line values for evaluating European and Japanese larch parent trees. Comparison made on breast height increment core samples. The solid line is the mean value and the dashed lines are one and two standard deviations ($s\bar{x}$) above and below the means.

LARCH AS A SOURCE OF KRAFT PULP

Introduction

There have been several pulping studies conducted in the last four years on Lake States-grown conifers, including the Project 3409 "larch" studies, that present an interesting story concerning the usefulness of European, Japanese, and hybrid larch as a source of kraft fiber. The studies include the investigations reported in Project 3409, Progress Reports One and Two, and work completed on juvenile jack pine and Eastern larch (*Larix laricina*, K. Koch) as part of a cooperative study with the U.S.F.S., Rhinelander, Wisconsin. Also, an Institute member company completed a very useful kraft pulping study on plantation-grown red pine* and jack pine that provides additional insight into the quality of Lake States plantation-grown conifer fiber. Permission was obtained to use part of those data, and it is the intent of the report that follows to compare larch, jack pine, and red pine pulping data and present an overview on the usefulness of larch fiber.

Pulping and Bleaching

One early concern about the use of European and Japanese larch for pulp was associated with extractive levels. If extractive levels were as high as reported in the literature, then pulp yield could be expected to be low and there would very likely be bleaching problems, either low brightness or high chemical requirements. The comments in the two sections that follow deal with the types of wood samples used in the several pulping studies undertaken and the kraft pulp yields obtained. The third section reviews the bleaching results obtained, and the final major section discusses the pulp strength data for kappa 50 and kappa 30 pulps.

*Red pine, which is also called Norway pine, *Pinus resinosa* Ait., is the most commonly planted Lake States conifer.

Sources of Wood

The wood sources used in the pulping work being summarized are described in Table IX. Of particular importance is the influence of tree species, age, and the presence of bark on resulting quality of chips and pulps produced. The only experimental materials that require some explanation are the three short rotation chip samples. They are from relatively small-size trees in which the entire above ground part of the tree was chipped (whole tree chips). For the hybrid larch, the bark content was reduced by screening and needle content kept to a minimum by removing most of the needles prior to chipping. The short rotation jack pine and short rotation Eastern larch were whole tree chips in which a vacuum air lift chip quality enhancement procedure was used to remove needles, bark, and other types of fines. The chip quality of the latter two sources was then further upgraded by screening and discarding material passing the 1/4-inch screen.

Pulp Yields and Kappa Number

Adequate pulp yields are all important in the selection of new pulping species. Typical kraft pulping procedures were used in these comparisons and the details, although not presented in this report, can be obtained from Project 3409 Progress Reports One and Two, and from a publication by Isebrands (3)*. Table X summarizes the pulp yields obtained. To assist the reader in comparing the yields of the various sources of wood, the unscreened yield data were adjusted to kappa 35. Using adjusted unscreened pulp yield data, jack pine has a pulp yield of 44-45%, red pine a pulp yield of 45-46%, Japanese larch a pulp yield of 45-46%, European larch a pulp yield of 48%, and hybrid larch a 49% yield. The eight-year-old whole tree chips which had from 2 to 23% bark had adjusted yields from 33 to 39%.

*Pulping conditions for the red pine pulps and the 25-year-old jack pine pulp were essentially identical to those for the larch pulps in Progress Reports One and Two.

TABLE IX

SUMMARY OF WOOD SOURCES

Wood Sample Description	Age, years	Bark, %	Specific Gravity (green volume basis)	Extractives, % Alcohol/Benzene	Hot Water
Red pine stud bolts[a]	57	0	0.44	--	--
Jack pine pulp-wood bolts	55	0	0.44	3.5	2.3
Red pine plantation trees[a]	22	0	--	--	--
Jack pine plantation trees[a]	25	0	0.39	--	--
European larch plantation trees	18	0	0.40	1.8	3.9
Japanese larch plantation trees	22	0	0.38	3.0	7.4
Hybrid larch plantation trees	23	0	0.41	2.5	4.2
Hybrid larch int. mang. trees[b]	8	23	0.34	2.4	7.4
Jack pine short rotation trees[b]	8	2	0.34	3.8	--
Eastern larch short rotation trees[b]	8	8	0.38	--	--

[a]Institute member company study.
[b]Part of cooperative study with U.S Forest Service - trees were from their short rotation intensive culture research program. The chips of the jack pine and eastern-larch were upgraded by vacuum air flotation and screening.

TABLE X

SUMMARY OF KRAFT PULP YIELDS

Wood Sample Description	Kappa No.	Unscreened Yield, %	Rejects, %	Pulp Fiber Length, Arith. Av., mm
Red pine stud bolts	40	46 (45.2)[a]	--	--
Jack pine pulpwood bolts	49	47 (44.9)	0.9	1.9
	34	44 (44.2)	0.6	1.9
Red pine plantation trees	35	46 (46)	--	--
Jack pine plantation trees	35	45 (45)	--	--
European larch plantation trees	53	51 (48.3)	11	1.6
	31	47 (47.6)	0.3	1.6
Japanese larch plantation trees	56	48 (44.8)	5.1	1.8
	32	46 (46.4)	2.2	1.8
Hybrid larch plantation trees	53	52 (49.3)	2.2	1.8
	35	49 (49)	1.4	1.7
Hybrid larch int. mang. trees	55	36 (33)	1.0	1.6
Jack pine short rotation trees	51	41 (38.6)	--	1.2
Eastern larch short rotation trees	49	39 (36.9)	--	1.2

[a]Yield adjusted to kappa 35.

European and the bark-free, 23-year-old hybrid larch had the best pulp yield of the chip sources investigated. Both sources, however, had high reject levels when pulped to kappa 50, and would require the repulping of rejects to attain the yield levels indicated. European and hybrid larch reject levels were normal when pulped to kappa levels of 31 to 35. Japanese larch yields were equivalent to those of red pine and were about 1% better than those of jack pine.

Bleaching Results

Another area of concern associated with the use of larch was the possible bleaching difficulties that might be encountered due to hot water extractives levels. Kappa 30 pulps were used in evaluating bleach requirements. A CEDED bleaching sequence was used, and Table XI summarizes several comparisons which provide some insight into the bleaching characteristics of larch. Each of the plantation sources of larch, and pulp that contained 25% pulp from the intensively managed 8-year-old hybrid, required more bleaching chemicals and had a lower final brightness than the jack pine control pulps. The 23-year-old hybrid larch plantation trees produced pulps that were most like jack pine in bleach requirements. Japanese larch pulps and pulps prepared from 8-year-old hybrid larch (23% bark) were the most difficult to bleach. The bleaching of pulps from 20- to 25-year-old larch does not appear to be a major problem but will be a little more costly than the jack pine control pulps because of the higher amount of chemical required to reach a specific brightness.

Pulp Strength Comparisons

Kappa 50 pulps that could be used for bag papers and kappa 30 pulps suitable for use in bleachable grades of paper and board were evaluated by preparing standard beater curves. Comparisons between the several sources of larch pulps and the red pine and jack pine control pulps are best made by plotting pulp strength at several different freeness levels and/or sheet densities. Another simpler, yet useful, approach is to compare pulp strength (tear, burst, tensile, etc.) at a constant sheet density. This approach was used to compare the several pulp sources described in Tables IX and X, and the results are presented in the sections that follow. Additionally, selected pulps were also evaluated by plotting tear factor over breaking length, which allows tear to be compared at a constant breaking length.

TABLE XI

BLEACHING RESULTS FOR KAPPA 30 PULPS
CEDED

Wood Pulp Description	Kappa No.	Chlorine Consumed, %	Chlorine Dioxide Consumed, %	Final GE Brightness %
Jack pine pulpwood bolts	34	7.0	1.60	90.3
European larch plantation trees	31	7.3	1.84	88.2
Japanese larch plantation trees	32	7.3	1.85	84.4
Hybrid larch plantation trees	35	7.0	1.53	88.3
75% Jack pine, 25% hybrid larch int. mang. trees	34	8.3	1.54	84.6
75% Jack pine, Japanese larch plantation	35	7.5	1.72	87.9
75% Jack pine, 25% European larch plantation	31	7.2	1.53	89.5
75% Jack pine, 25% hybrid larch plantation	31	7.0	1.50	90.2

Kappa 50 Pulps

Table XII summarizes the handsheet strength properties of the kappa 50 pulps. For use as bag papers, tear factor and tensile energy absorption (TEA) are very important. To facilitate comparisons of these properties, the

TABLE XII

KAPPA 50 UNBLEACHED PULP STRENGTH COMPARISONS[a]

Pulp Sample Description	Age, Years	Kappa No.	Pulp CSF, mL	Sheet Density	Breaking Length, km	Burst Factor	Tear Factor	TEA, kg M/m^2
Jack pine pulpwood bolts (control)	55	49	510	0.72	10.8	87	122 (100)[b]	14.6 (100)[b]
European larch plantation trees	18	53	445	0.72	11.0	84	114 (93)	14.7 (101)
Japanese larch plantation trees	22	53	210	0.71	10.8	86	115 (94)	15.5 (106)
Hybrid larch plantation trees	23	56	280	0.71	10.2	83	141 (116)	14.6 (100)
Hybrid larch int. mang. trees	8	55	330	0.69	8.9	66	99 (81)	13.9 (95)
Eastern larch short rotation trees	8	49	400	0.72	10.5	78	84 (69)	--
Jack pine short rotation trees	8	51	400	0.72	9.8	69	80 (66)	--

[a]Comparisons made at comparable sheet density.
[b]Values in parentheses are percentages of the jack pine pulpwood control pulps.

55-year-old jack pine strength values for tear factor and TEA were given a value of 100 and relative values calculated for the other sources of pulp. Unfortunately kappa 50 pulp data were not available for the red pine and jack pine plantation wood. Comparing kappa 50 values for tear factor, the hybrid larch plantation pulps (23-year-old trees) had the highest value (116) and the short rotation jack pine (8-year-old trees) the lowest tear (66). European and Japanese larch plantation tree tear factor values were 6-7% lower than those of the jack pine control pulp. Comparing TEA values, the data for the short rotation trees were not available, and the differences in TEA for other sources of pulp varied very little (95 to 106) from that of jack pine control pulps. Burst factor was lowest for the short rotation (juvenile) pulp sources, and 18- to 23-year-old larch plantation trees had values that were comparable to the jack pine control pulp.

When tear factor was plotted over breaking length (Fig. 6), the hybrid larch plantation pulps had the highest tear factor/breaking length combination; the values for European larch and Japanese larch plantation pulps appeared comparable to the jack pine control pulp; and the three short rotation (juvenile pulps) had the poorest tear factor/breaking length strength values.*

Kappa 30 Pulps

Table XIII summarizes the available handsheet strength data for the kappa 30 bleached pulps. The comparisons in this instance, as with the kappa 50 pulps, were made at comparable sheet density (0.70 - 0.72 g/cc).** Using this approach, there was a moderate amount of variation in pulp freeness levels, i.e., from 325 to 670. Pulps from short rotation trees were not part of this comparison because of the anticipated bleaching problems associated with whole tree chips containing varying levels of bark. The only exception to this statement is that a mixture of 75% jack pine control chips was cooked with 25% 8-year-old hybrid larch chips, and the resulting 30 kappa pulp was bleached and tested for strength properties (Table XIII).

*Pulps are refined to improve breaking length. Refining causes a loss in tearing strength. Pulps that develop good breaking length (8 to 10 km) and retain high tear are considered superior.

**Except for the red pine plantation tree pulps, which had a sheet density of 0.75.

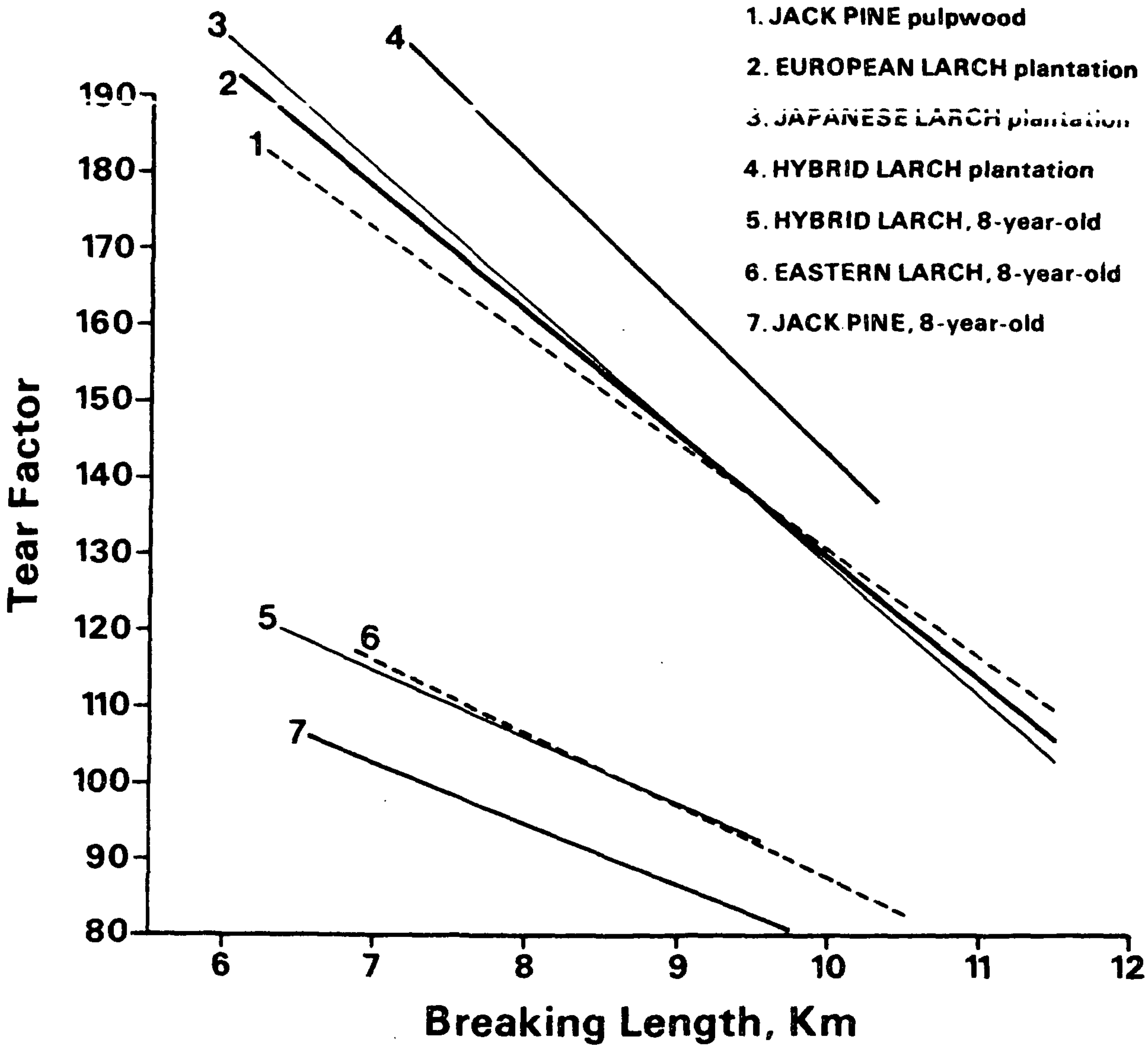

Figure 6. Tear factor vs. breaking length at 50 kappa.

TABLE XIII

KAPPA 30 BLEACHED PULP STRENGTH COMPARISONS[a]

Pulp Sample Description	Age, Years	Kappa No.	Pulp CSF, mL	Sheet Density g/cc	Burst Factor	TEA, kg M/m^2	Breaking Length, km	Tear Factor
Jack pine pulpwood bölts (control)	55	34	640	0.71	85	17.8	10.2 (100)[a]	136 (100)[a]
European larch plantation trees	18	31	620	0.71	74	14.8	10.2 (93)	161 (118)
Japanese larch plantation trees	22	32	465	0.72	90	17.9	11.4 (112)	126 (93)
Hybrid larch plantation trees	23	35	325	0.72	89	16.8	11.0 (108)	144 (106)
* * * * * * *								
75% jack pine, 25% hybrid larch (int. mang. trees)	55 8	34	670	0.70	73	15.3	9.1 (89)	154[b] (113)
Red pine plantation trees	22	35	500	0.75	74	--	8.6 (84)	97 (71)
Jack pine plantation trees	25	35	475	0.72	75	--	8.7 (85)	117 (86)
Red pine stud bolts	57	40	465	0.71	84	--	8.8 (86)	145 (107)

[a]Comparisons made at comparable sheet density; values in parentheses are percentages of the jack pine pulpwood bolt control pulps.

[b]This value is misleading - upon further refining sheet density increased rapidly and tear factor decreased to values comparable to those of the jack pine control pulp.

Breaking length and tear factor are important to bleachable grade pulps. To facilitate the comparison of these two properties, the jack pine control pulps were assigned a value of 100, and the tear and breaking length data for the other sources of pulp were given values that were percentages of the jack pine control pulps (see values in parentheses in Table XIII). When tear factor values for the different types of pulps are compared, the pulp from European larch plantation trees (age 18) had the highest tear and the red pine plantation pulps (age 22) had the lowest tearing strength (29% less than the jack pine control pulps). When this same comparison is made for breaking length, the Japanese larch pulps had the highest value, and the red pine plantation pulps again had the lowest value. An interesting and somewhat unexpected result was the high tear and the acceptable breaking length values obtained for pulp produced from the mixture of 75% jack pine and 25% juvenile hybrid larch. This higher than expected tear value, however, was associated with a low level of refining. At higher refining levels tear factor decreased and was similar to the jack pine control pulp.

To provide an additional insight into the differences between the kappa 30 pulps, tear factor was plotted over breaking length for selected pulps. These results are summarized in Fig. 7*. Pulps that develop adequate breaking length (upon refining), yet maintain good tearing strength are generally considered to be superior to those pulps that develop adequate breaking length but, as a result,have low tearing strength. When these comparison criteria were applied, the red pine and jack pine plantation pulps were the least desirable, and the hybrid larch plantation (age 23) pulps and Japanese larch plantation (age 22) pulps appeared to be a little better than the jack pine control pulps and the most desirable of pulps evaluated.

*Except the red pine plantation tree pulps which had a sheet density of 0.75.

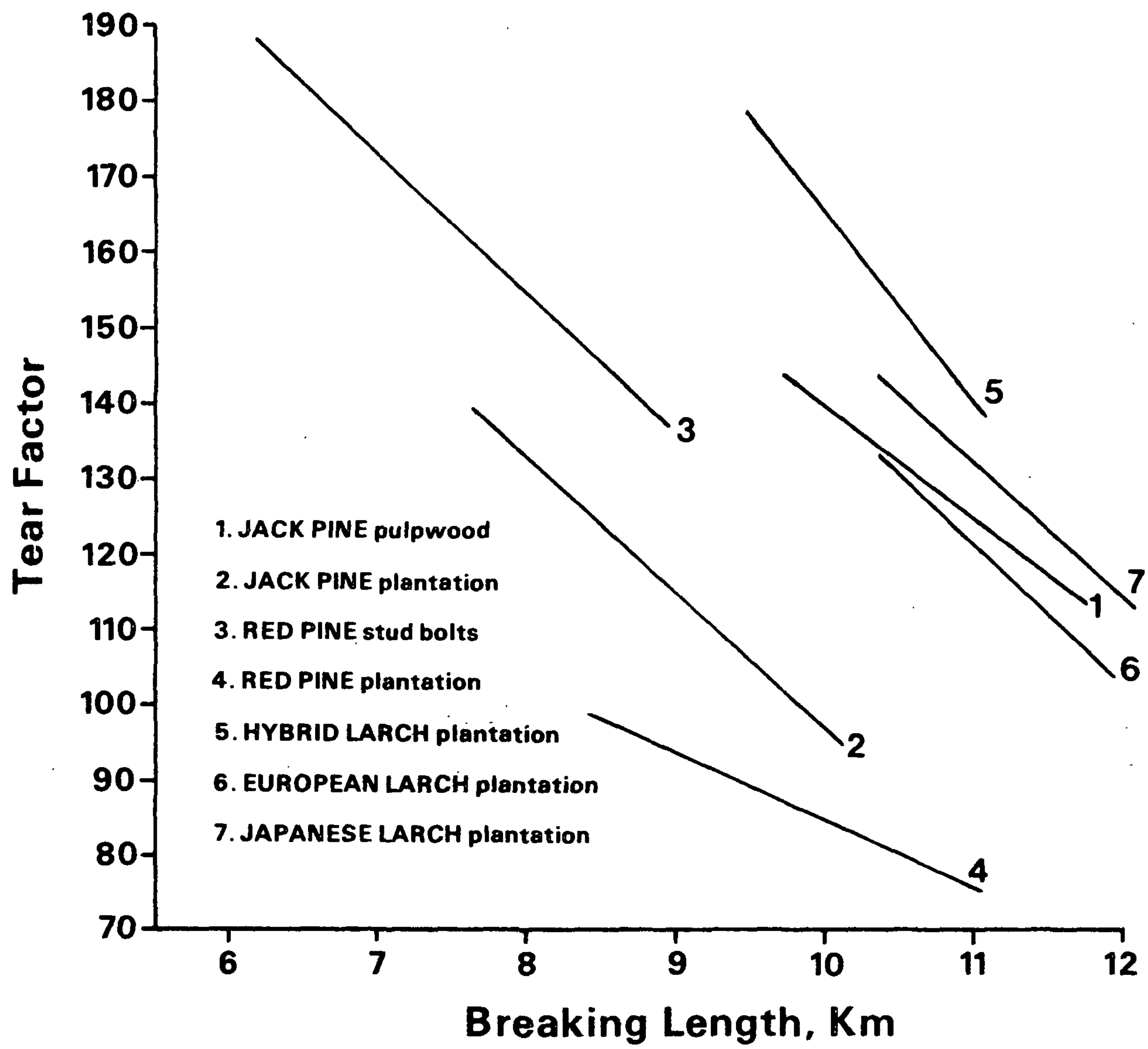

Figure 7. Tear factor vs. breaking length for 30 kappa bleached pulps.

In many instances the reason for adding the conifer fiber to hardwood pulps is to improve tearing strength and breaking length (tensile strength). One reason this is important is that wet strength is improved and machine speed can be increased. The kappa 50 and kappa 30 comparisons indicate that European, Japanese, and hybrid larch are superior to comparable-age jack pine and red pine for addition to hardwood pulps. The use of red pine thinnings for pulpwood is expected to increase; as this occurs, the inferiority of red pine as pulpwood will become more and more evident.* This is no small matter when one considers the millions of red pine being planted each year in the Lake States and Northeast.

Pulps from Jack Pine/Larch Mixtures

Knowing that in most instances larch will not be pulped alone, mixtures of 75% jack pine and 25% larch were prepared and evaluated. Chip mixtures were pulped and evaluated in studies involving the chip sources of European larch plantation trees, Japanese larch plantation trees, hybrid larch plantation trees, and the intensively managed 8-year-old hybrid larch (Table XIII). Details of these comparisons are not presented at this time but can be obtained from Project 3409, Progress Reports One and Two, and publications by Isebrands et al. (3) and Einspahr et al. (4).

The results of this chip mixture approach produced few surprises. No problems were encountered in cooking rate, rejects, or pulp yields. Values for most parameters measured were intermediate between those for the jack pine control and the values for the larch chip sources when pulped alone, usually being closer to those of the jack pine control.

*It should be noted that these conclusions are based upon a limited amount of data and should perhaps be rechecked in view of the implications.

Refining rates, sheet density, and handsheet strength properties also followed a similar pattern, i.e., being intermediate but more nearly equal to the jack pine control pulp values. The one somewhat unexpected result was the considerable improvement in the strength (particularly tear factor) that occurred when the relatively low quality juvenile hybrid larch chips were cooked with 75% jack pine control chips. This was apparently due in part to the better bonding imparted by the juvenile thin-walled fibers of the 8-year-old hybrid larch. This pulp mixture, however, did not respond well to refining and at lower freeness levels and higher sheet densities had lower tear than the other pulps.

Pulping Summary

Based upon the information presented in this report, and the data presented and discussed in Project 3409, Progress Reports One and Two, the following conclusions concerning larch kraft pulps were obtained:

1. Hybrid larch chip sources and chip mixtures with jack pine cooked at rates similar to the jack pine control chips.

2. European larch chips and the chip mixture with jack pine cooked at rates modestly faster than the jack pine control chips.

3. The Japanese larch chips and the chip mixture with jack pine cooked at a slightly slower rate than the jack pine control chips.

4. The unscreened pulp yields for all chip sources were adjusted to a kappa number of 35. The resulting adjusted yields were as follows: jack pine - 44 to 45%; red pine - 45 to 46%; Japanese larch - 45 to 46%; European larch - 48%; and hybrid larch - 49%.

The juvenile (8-year-old) whole tree hybrid larch and Eastern larch had adjusted yields of 33 and 37%, respectively.

5. Cooking larch chips and chip mixtures containing 25% larch to kappa 50 resulted in larger than acceptable levels of screen rejects that dropped to normal levels by cooking to kappa 30 to 35.

6. European larch refined at similar rates and had kappa 50 pulp strengths that were comparable to those of the jack pine control pulps, whereas hybrid and Japanese larch refined with more difficulty and developed lower kappa 50 breaking length.

7. When compared to the jack pine control pulps, Japanese larch had similar, and hybrid larch had greater, kappa 50 tearing strength.

8. Tensile energy absorption of the larch kappa 50 pulps, an important property of bag and wrapping papers, was comparable to the values for the jack pine control pulps.

9. When compared to the jack pine control pulps, kappa 50 pulps from the juvenile sources of larch (and jack pine) had 20-35% lower burst and tearing strength and similar breaking length values.

10. The hybrid larch kappa 30 pulp (age 23) had bleaching chemical requirements and a final brightness not greatly different from those of the jack pine control pulps.

11. The European larch kappa 30 pulp was slightly more difficult to bleach; the Japanese larch kappa 30 pulp and the kappa 30 pulp containing 25% juvenile hybrid larch pulp (23% bark) were the most difficult to bleach.

12. Pulping larch and larch/jack pine mixtures containing European, Japanese, and age-23 hybrid larch to kappa 30, followed by bleaching, resulted in pulps that refined and had strength properties very similar to those of the jack pine control pulps.

13. When kappa 30 bleached pulps from larch were compared with comparable-age red pine and jack pine plantation pulps, the larch pulps were superior in tear, burst, and breaking length. Red pine plantation pulps had about 29% lower tear and 16% lower breaking length than the jack pine control pulps.

14. Limited tests, in which larch kappa 30 pulps from the 18- to 23-year-old plantation trees were mixed with hardwood pulps, demonstrated that larch could be satisfactorily substituted for the 55-year-old jack pine kappa 30 control pulp.

PLANS FOR 1983-1984

Plans for the coming year indicate the overall level of activity will be about the same as that of last year. Parent tree selection will continue with about equal emphasis on European and Japanese larch. We plan to make an additional 15-20 selections and work on the larch selection index, which will allow the comparison of widely scattered parent trees. The selection index will be completed and evaluated during the coming year.

Propagation of selected trees and the establishment of grafted trees in the IPC scion arboretum will receive a major amount of attention. The estimated number of grafts is expected to exceed 650. At present there are 45 larch clones in the scion arboretum, and 27 additional clones are scheduled to be field planted this spring.

Work on isozyme procedures for evaluating relatedness of parent trees will be continued. Investigations are expected to include developing procedures for using acid phosphatase, cytochrome oxidase, and glutamic-oxalacetic transaminase isozymes for relatedness comparisons. Developed techniques will be tried on additional known geographic sources and additional half-sib trees. To further verify the definitiveness of this approach, several full-sib progeny groups will be required. The needed full-sibs are presently not available, and if we cannot locate suitable sources, controlled crossing work will be required to provide the needed trees.

Parent tree wood quality evaluations will continue, and as additional wood quality data are acquired, the base lines for specific gravity, fiber length, and extractives will be updated. No pulping is planned for the coming year.

Hybrid larch seed has been acquired. Seedbeds will be established and seedlings produced for use in a major field trial that will be planted in 1985. The planned trial will be a conversion planting that compares two site preparation methods, on four soils (geographic locations), and containers vs. bare root planting stock. A single F_1 hybrid larch seed source will be used throughout the trial. Each of the four test sites will be 13 to 14 acres in area. A fifth backup site is being developed and will be planted if enough suitable planting stock is available.

ACKNOWLEDGMENTS

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LITERATURE CITED

1. Armson, K.A., Fung, M., Bunting, W.R. Operational rooting of black spruce cuttings. Journal of Forestry, June 1980:341-3.

2. Kleinschmit, J. A programme for large-scale cutting propagation of Norway spruce. New Zealand Journal of Forestry Science 4(2):359-66(Oct., 1974).

3. Isebrands, J. G., Einspahr, D. W., Phelps, J. E., and Crist, J. B. Kraft pulp and paper properties of juvenile hybrid larch grown under intensive culture. Tappi 65(9):122-6(1982).

4. Einspahr, D. W., McDonough, T. J., and Joachimides, T. Kraft pulping characteristics of European, Japanese, and European x Japanese larch hybrids. Tappi, in press, 1983.

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APPENDIX

TABLE XIV

TREE INFORMATION SHEETS

PROJECT TREE NO. ____________ DATES: Discovered ____________
Measured ____________
LOCATION: ____________________ Cores Taken ____________

HEIGHTS (feet):
Total ________
3 inch top ________

DIAMETERS (inches):
D.B.H. ________
16.5 ft. ________
Rings/inch: ________

BARK THICKNESS (inches):
D.B.H. ________
16.5 ft. ________
Age: ____+________

FORM:
1.) Stem (1-5) ______ p - g
2.) Branches
a) number ______
b) angle (°) ______
c) weight (1-5) ______ g - p
d) natural pruning (1-5) ______ p - g

3.) Crown
a) diameter (ft) ____________
b) exposure (0-4 sides) ____________
c) class ____________
d) deformities ____________

SOIL INFORMATION:

Horizon	Thickness	Texture	Remarks
A°	______	______	
A_1	______	______	
A_2	______	______	
B	______	______	
Water Table	____________		

Topographic Information
Aspect ______
Slope ______ %
Topographic Position ______

Site Index ______

ASSOCIATED SPECIES: ____________________

DISEASE RECORD: No. Cankers, etc. ____________________

INSECT RECORD: ____________________

OTHER INJURY: ____________________

LOCATION WOOD SAMPLES: ____________

LEAF COLLECTION:
Number ____________
Location in crown ____________

CALCULATIONS:
Form Factor ________
Tree Volume ________
Crown Area ________
Selection Index ________
Specific Gravity ________
Fiber Length (age 30) ________

Discovered by: ____________ Measured by: ____________

REMARKS: Painted: ____________

(over) Form S-1

APPENDIX

TABLE XIV (Continued)

LOCATION: State ______________ County ______________ Twp. ____________________

Range ______________ Sec. ______________ Other ______________________________

MAP OF LOCATION:

OWNERSHIP INFORMATION:

CORE INFORMATION: Number Taken _______ Increment Borer Number ______________

Equilibrium Moisture Content ______%______ Oven Dry Wt. Conversion Factor ________

	Core No.1	Core No.2	Core No.3	Core No.4	Core No.5	Core No.6	Average
Length (mm)	_______	_______	_______	_______	_______	_______	
Eq. Mo. Con. weight	_______	_______	_______	_______	_______	_______	
O.D. Wt.	_______	_______	_______	_______	_______	_______	
Volume (cc)	_______	_______	_______	_______	_______	_______	
Sp. Gr.	_______	_______	_______	_______	_______	_______	_______

APPENDIX

TABLE XV

EUROPEAN LARCH PARENT TREE SELECTIONS
SEED ORIGIN

Material	Origin	Distribution Group[a]	Cooperator and Location
LD-10-79	Styria, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-11-79	Styria, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-12-79	Styria, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-1-80	Breslau, Poland	Sudeten	Iowa Conservation Commission, McGregor, IA
LD-2-80	Breslau, Poland	Sudeten	Iowa Conservation Commission, McGregor, IA
LD-3-80	Wroclaw, Poland	Sudeten	Iowa Conservation Commission, McGregor, IA
LD-4-80	Breslau, Poland	Sudeten	Iowa Conservation Commission, McGregor, IA
LD-5-80	Styria, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-6-80	Styria, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-7-80	Styria, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-8-80	SSUI[b]		Wisconsin DNR, LaCrosse, WI
LD-9-80	SSUI[b]		Wisconsin DNR, LaCrosse, WI
LD-10-80	SSUI[b]		Wisconsin DNR, LaCrosse, WI
LD-11-80	Tirol, Austria	Alpen	Wisconsin DNR, LaCrosse, WI
LD-12-80	Rundforbi, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-13-80	Rundforbi, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-14-80	Rundforbi, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-15-80	Rundforbi, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-16-80	Zagnansk, Poland	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-17-80	Zagnansk, Poland	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-18-80	SSUI[b]	SSUI	
LD-19-80	Nodebo, Denmark	Sudeten[b]	U.S. Forest Service, Rhinelander, WI
LD-20-80	Kronborg, Denmark	SSUI[b]	U.S. Forest Service, Rhinelander, WI
LD-21-80	Palsgaard, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-22-80	Nodebo, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-23-80	SSUI[b]	SSUI	Hammermill Paper Co., Warren, PA
LD-24-80	SSUI[b]	SSUI	Hammermill Paper Co., Warren, PA
LD-25-80	SSUI[b]	SSUI	Hammermill Paper Co., Cattaraugus, NY
LD-26-80	SSUI[b]	SSUI	Hammermill Paper Co., Warren, PA
LD-27-80	SSUI[b]	SSUI	Hammermill Paper Co., Warren, PA
LD-28-80	SSUI[b]	SSUI	Hammermill Paper Co., Mina Hollow, PA
LD-29-80	SSUI[b]	SSUI	Hammermill Paper Co., Mina Hollow, PA
LD-30-80	SSUI[b]	SSUI	Hammermill Paper Co., Mina Hollow, PA

See end of table for footnotes.

APPENDIX

TABLE XV (Continued)

EUROPEAN LARCH PARENT TREE SELECTIONS
SEED ORIGIN

Material	Origin	Distribution Group[a]	Cooperator and Location
LD-1-81	Rundforbi, Denmark	Sudeten	U.S. Forest Service, Rhinelander, WI
LD-2-81	Zagnansk, Poland	SSUI	U.S. Forest Service, Rhinelander, WI
LD-3-81	Aroretet, Denmark	SSUI	U.S. Forest Service, Rhinelander, WI
LD-4-81	Palsgaard, Denmark	SSUI	U.S. Forest Service, Rhinelander, WI
LD-5-81	Nodebo, Denmark	SSUI	U.S. Forest Service, Rhinelander, WI
LD-6-81	Palsgaard, Denmark	SSUI	U.S. Forest Service, Rhinelander, WI
LD-7-81	SSUI[b]	SSUI	Hammermill Paper Co., Warren, PA
LD-8-81	SSUI[b]	SSUI	Hammermill Paper Co., Potter, PA
LD-9-81	SSUI[b]	SSUI	Hammermill Paper Co., Potter, PA
LD-10-81	SSUI[b]	SSUI	Hammermill Paper Co., Potter, PA
LD-11-81	SSUI[b]	SSUI	Hammermill Paper Co., Warren, PA
LD-12-81	SSUI[b]	SSUI	Scott Paper Co., Waterville, ME
LD-13-81	SSUI[b]	SSUI	Scott Paper Co., Waterville, ME
LD-1-82	Zagnansk, Poland	Polen	U.S. Forest Service, Rhinelander, WI
LD-2-82	Lot 55, Sweden	SSUI	U.S. Forest Service, Rhinelander, WI
LD-3-82	Zagnansk, Poland	Polen	U.S. Forest Service, Rhinelander, WI
LD-4-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-5-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-6-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-7-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-8-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-9-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-10-82	Berthierville, Quebec	SSUI	U.S. Forest Service, Rhinelander, WI
LD-11-82	Dobris, Czechoslovakia	SSUI	U.S. Forest Service, Rhinelander, WI
LD-12-82	Dobris, Czechoslovakia	SSUI	U.S. Forest Service, Rhinelander, WI
LD-13-82	Zabreh-Dubicko, Czechoslovakia	SSUI	U.S. Forest Service, Rhinelander, WI
LD-14-82	Ruda nad Morovou, Czechoslovakia	SSUI	U.S. Forest Service, Rhinelander, WI
LD-15-82	Skarzysko, Poland	Polen	U.S. Forest Service, Rhinelander, WI
LD-16-82	Skarzysko, Poland	Polen	U.S. Forest Service, Rhinelander, WI
LD-17-82	Schlitz, Germany	SSUI	U.S. Forest Service, Rhinelander, WI
LD-18-82	Skarzysko, Poland	Polen	U.S. Forest Service, Rhinelander, WI
LD-19-82	Schlitz, Germany	SSUI	U.S. Forest Service, Rhinelander, WI
LD-20-82	SSUI	SSUI	Diamond International, Milo, ME
LD-21-82	SSUI	SSUI	Diamond International, Milo, ME
LD-22-82	Pinczow, Poland	Polen	State of New Hampshire, Hillsboro, NH
LD-23-82	Salzburg, Austria	Alpen	State of New Hampshire, Hillsboro, NH
LD-24-82	Brenensky, Czechoslovakia	Sudeten	State of New Hampshire, Hillsboro, NH
LD-26-82	Salzburg, (Bluhnbach) Austria	Alpen	State of New Hampshire, Hillsboro, NH

[a]Four separate distributional groups are recognized within the geographical range of European larch: Alpen, Sudeten, Tatra, and Polen plus several smaller outliers in Rumania. Major genetic differences are found between and within these groupings (13).

[b]Seed source under investigation.

APPENDIX

TABLE XVI

JAPANESE LARCH PARENT TREE SELECTIONS
SEED ORIGIN

Material	Origin	Cooperator and Location
LL-4-59,S-1	Nagano Prefecture, Japan	IPC Larch Trial III, Clintonville, WI
LL-4-59,S-2	Nagano Prefecture, Japan	IPC Larch Trial III, Clintonville, WI
LL-12-59,S-1	Hokkaido, Japan	IPC Larch Trial III, Clintonville, WI
LL-1-80	Nagano Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-2-80	Nagano Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-3-80	Nagano Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-4-80	Nagano Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-5-80	Tochigi Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-6-80	Tochigi Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-7-80	Nagano Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-8-80	Nagano Prefecture, Japan	Iowa Conservation Commission, McGregor, IA
LL-9-80	Latitude 35° 54', longitude 137° 34'	Packaging Corporation of America, Bear Lake, MI
LL-10-80	Latitude 35° 54', longitude 137° 34'	Packaging Corporation of America, Bear Lake, MI
LL-11-80	SSUI[a]	Pennsylvania Bureau of Forestry, Harrisburg, PA
LL-12-80	SSUI[a]	Pennsylvania Bureau of Forestry, Harrisburg, PA
LL-13-80	SSUI[a]	Pennsylvania Bureau of Forestry, Harrisburg, PA
LL-14-80	SSUI[a]	Pennsylvania Bureau of Forestry, Harrisburg, PA
LL-15-80	SSUI[a]	Pennsylvania Bureau of Forestry, Harrisburg, PA
LL-16-80	SSUI[a]	Pennsylvania Bureau of Forestry, Harrisburg, PA
LL-17-80	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-18-80	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-19-80	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-20-80	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-21-80	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-22-80	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-23-80	SSUI[a]	Glatfelter Pulp Wood Co., Hershey, PA
LL-24-80	SSUI[a]	Glatfelter Pulp Wood Co., Hershey, PA
LL-1-81	SSUI[a]	U.S. Forest Service, Rhinelander, WI
LL-3-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-4-81	Gumma Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-6-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-7-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-8-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-9-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-10-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-11-81	Nagano Prefecture, Japan	U.S. Forest Service, Rhinelander, WI
LL-12-81	SSUI[a]	Scott Paper Co., Oxford City, ME
LL-2-59,S-1	Nagano Prefecture, Japan	IPC Larch Trial III, Clintonville, WI
LL-5-82	Hokkaido, Japan	IPC Larch Trial I, Eagle River, WI
LL-6-82	Hokkaido, Japan	IPC Larch Trial I, Eagle River, WI
LL-7-82	SSUI	International Paper Co., Readfield, ME
LL-8-82	SSUI	Glatfelter Pulp Wood Co., Fort Littleton, PA
LL-9-82	Yokohama, Japan	Glatfelter Pulp Wood Co., Huston, PA
LL-10-82	Yokohama, Japan	Glatfelter Pulp Wood Co., Maddensville, PA
LL-11-82	Yokohama, Japan	Glatfelter Pulp Wood Co., Huston, PA
LL-12-82	Yokohama, Japan	Glatfelter Pulp Wood Co., Huston, PA

[a]See source under investigation.

GLOSSARY

FOREST GENETICS TERMS

Clone - A group of plants derived from a single individual (ortet) by asexual reproduction. All members (ramets) of a clone have the same genotype and, consequently, tend to be uniform.

Compression wood - Wood of dense structure formed at the bases of some trees and on the underside of branches in conifers.

Cyclophysis - Abnormal growth that occurs in a graft when scion material is collected from too low an area in the crown.

Cytochromes - Cytochrome a, b, and c are heme-containing proteins widely occurring in cells and acting as oxygen carriers during cellular respiration.

F_1 generation - The first generation of a mating. If each parent is true breeding (homozygous), the F_1 individuals always resemble each other.

F_2 generation - The second generation successive to the parents and produced by crossing or selfing the F_1 individuals. The individuals within an F_2 generation characteristically vary greatly when their F_1 parent or parents are heterozygous.

F_3 generation - The third generation produced by intercrossing or selfing F_2 individuals. Individuals within an F_3 generation characteristically vary greatly.

Full-sib - Progeny, irrespective of sex, having the same male and female parent but from separate fertilizations.

Half-sib - Progeny, irrespective of sex, having only one parent in common.

Hedging - Reducing a plant to a more juvenile stage by repeatedly cutting it back and forcing a large number of shoots.

Heterozygosity - Presence in the same plant of both the dominant and recessive gene. A heterozygous individual characteristically does not breed true.

Homozygosity - Presence in a plant of either the dominant or recessive gene but not both. A homozygous individual breeds true when mated with the same genotype for the character(s) in question.

Inbreeding depression - Loss of vigor and/or fertility through intercrossing or selfing related organisms.

Isozyme (isoenzyme) - Multiple forms of a single enzyme. Isozymes often have different isoelectric points and therefore can be separated by electrophoresis.

Plagiotropism - A growth response to gravity, so that the axis of the plant member makes an angle other than 90° with the line of the gravitational field. See cyclophysis and topophysis.

Propagule - A plant part, such as a bud, tuber, root, or shoot, used to reproduce an individual asexually.

Provenance - The original geographic source of seed or propagules.

Topophysis - Abnormal growth that occurs in a graft when scion material is collected from the wrong branch positions.

PULPING TERMS

Breaking length - The length of a strip, usually expressed in meters, which would break of its own weight when suspended vertically.

Bursting strength - The hydrostatic pressure in pounds per square inch required to produce rupture of the material when pressure is applied at a controlled increasing rate through a rubber diaphragm to a circular area.

CEDED bleaching - Sequence of chlorination, alkali extraction, chlorine dioxide, extraction, and chlorine dioxide.

Coarseness - The weight per unit length of a single fiber. Usually expressed as mg/100 m and considered to be useful in predicting fiber behavior in papermaking.

Freeness - A measure of the rate at which water drains from a stock suspension through a wire mesh screen or a perforated plate. It is also known as "slowness" or "wetness" according to the type of instrument used in its measurement and the method of reporting results.

Furnish - The mixture of various materials that are blended in the stock suspension from which paper or board is made. The chief constituents are the fibrous material (pulp), sizing materials, wet-strength or other additives, fillers, and dyes.

Handsheet - A sheet made from a suspension of fibers in water, with or without the addition of sizing, loading, or coloring agents. Each sheet is formed separately by draining a pulp suspension on a stationary mold called a sheet mold. It is generally used for testing the physical properties of the pulp and/or the combinations of pulp with other material, in which case the sheet must be formed in accordance with standard procedures.

Kappa no. - Related to the amount of lignin left in the pulp. Decreasing numbers mean less lignin left in the pulp.

Tearing resistance - The force required to tear a specimen under standardized conditions. There are three terms in common usage: (1) internal (or continuing) tearing resistance, wherein the edge of the specimen is cut prior to the actual tear. The value is commonly expressed in grams of force required to tear a single sheet. (2) "Edge tearing resistance." (3) Torsion tearing resistance of paper or paperboard is the energy expended in propagating a tear when the tearing force is applied in such a manner as to create a twist or torque.

Tensile strength - The force, parallel with the plane of the paper, required to produce failure in a specimen of specified width and length under specified conditions of loading. This definition must be distinguished from that which is commonly used in engineering practice and which expresses the tensile strength in force per unit area. In the paper industry, it is expressed as load per unit width or as "breaking length."

Zero-span tensile strength - The tensile strength of a sheet of fibrous material, measured with special jaws, at an apparent initial span of zero. It is an indication of the strength of the material comprising the fiber.